SYSTEM AND METHOD FOR INCREASING SIGNAL-TO-NOISE RATIO IN OPTICAL-BASED SENSOR SYSTEMS

FEDERALLY-SPONSORED RESEARCH AND DEVELOPMENT

The System and Method for Increasing Signal-to-Noise Ratio in Optical Based Detection Systems was developed with funds from the United States Department of the Navy. Licensing inquiries may be directed to Office of Research and Technical Applications, Space and Naval Warfare Systems Center, San Diego, Code 2112, San Diego, Calif., 92152; telephone 619-553-2778; email: T2@spawar.navy.mil, reference Navy Case No. 98183.

BACKGROUND

Extensive work has been performed to utilize optical systems for high-end sensor designs. However, unlike digital communications where a signal is interpreted as either a logic high or logic low value, analog sensors must be able to discern a wide range of continuous values. The ability to extend an analog sensor's range of continuous values, as well as increase its resolution within this range, greatly enhances the utility and functionality of such a sensor for high-end applications.

To increase dynamic range and resolution within a dynamic range, feedback control can be used. Feedback control can come from a sensor system illuminated by a light emission source or from a back-reflection of light from a semi-transparent glass cap that is used to seal a discrete light emission system. Both examples can be found in commercially available systems.

While useful, both approaches have several drawbacks and do not fully realize the signal-to-noise ratio (SNR) potential of a light emission system. For example, if a semi-transparent glass cap is mounted directly behind a light source to create back-reflections to a diode, some light may be directly reflected back to the light source. Unfortunately, such feedback directly into the light source can decrease the SNR. This approach can also preclude direct packaging of a light source with the optical sensor system, increasing the size of the optical system. Generally, only light that is reflected at a large enough angle can travel beyond the edge of the light emission source and become collected photo current in a photodiode mounted behind the light source. This unfortunately can reduce the total amount of light available, decreasing the SNR of the respective photodiode. A decrease in SNR makes it more difficult to accurately control and adjust the light source.

There is a need for a system and method for increasing the SNR in optical based detection systems.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a cross-section view of an embodiment of a sensor in accordance with the System and Method for Increasing Signal-to-Noise Ratio in Optical Based Sensor Systems.

FIG. **2** shows a plan view of an embodiment of a sensor in accordance with the System and Method for Increasing Signal-to-Noise Ratio in Optical Based Sensor Systems.

FIG. **3** shows a cross-section view of an embodiment of a system in accordance with the System and Method for Increasing Signal-to-Noise Ratio in Optical Based Sensor Systems.

FIGS. **4**A and **4**B show block diagrams illustrating systems having feedback control in accordance with the System and Method for Increasing Signal-to-Noise Ratio in Optical Based Sensor Systems.

FIG. **5** shows a flowchart illustrating an embodiment of a method in accordance with the System and Method for Increasing Signal-to-Noise Ratio in Optical Based Sensor Systems.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

Referring to FIGS. **1** and **2**, FIG. **1** shows a cross-section view of an embodiment of a sensor **100** in accordance with the System and Method for Increasing Signal-to-Noise Ratio in Optical Based Sensor Systems, while FIG. **2** shows a plan view of sensor **100**. In some embodiments, sensor **100** is a photodiode sensor, such as a monitor photodiode sensor. Sensor **100** includes a body **110**, which also serves as a cathode, an anode **114** in contact with body **110**, an anode contact **120**, and a cathode contact **130**. In some embodiments, sensor **100** includes a transparent coating **112** disposed on the top surface of sensor **100**. The spacing between body **110** and anode **114** may be determined by the required breakdown voltage of the system, where a large spacing implies a larger breakdown voltage, but at the expense of increased surface leakage currents. The thickness of sensor **100** (see dimension D**4** in FIG. **1**) may be varied to meet specific application requirements. As an example, the thickness of sensor **100** may be 125 μm. Depending on the method of assembly and packaging, anode contact **120** and cathode contact **130** may either be located on the same side of sensor **100** or on opposite sides of sensor **100**.

In some embodiments, anode **114** may be ring-shaped. In some embodiments, anode **114** is annular-ring shaped. In some embodiments, anode **114** comprises other shapes, such as square or oval. In some embodiments, anode **114** is the optical sensing portion of sensor **100**. In operation, anode **114** may sense optical energy emitted from an optical source, such as a laser or light-emitting diode (LED), that would otherwise diverge and be lost to the system.

Sensor **100** includes an aperture **150** therein. In some embodiments, optical energy that is not sensed by anode **114** passes through aperture **150**. In some embodiments, aperture **150** is located within the center of anode **114**. In some embodiments, aperture **150** has a greater diameter D**1** at the top of sensor **100**, a lesser diameter D**2** at the bottom of sensor **100**, and a sloping-surface connecting the upper part of aperture **150** with the lower part of aperture **150**. As an example, diameter D**1** may be 20 μm and diameter D**2** may be 15 μm. In some embodiments, aperture **150** has a uniform diameter throughout sensor **100**. In some embodiments, anode **114** has an inner radius separated from the greater diameter D**1** by distance D**3**. As an example, distance D**3** is 5 μm. In other embodiments, the inner radius of anode **114** is defined by the perimeter of aperture **150**. The dimensions of aperture **150** and anode **114** may vary based upon the spacing between an optical energy source and sensor **100**, as well as the amount of optical energy required to be incident on a target detector (see FIG. **4**). Aperture **150** may be created using a Deep Reactive Ion Etch process, Ion Milling, laser etching or other equivalent process as recognized by one having ordinary skill in the art.

In embodiments wherein anode **114** is ring-shaped or circular, anode **114** may sense optical energy for each angle θ, and integrate sensed light for each angular range, such as θ_1 to θ_2 shown in FIG. **2**. In some embodiments, anode **114** may sense and integrate optical energy at an angular range of about